

including at least a first state, a second state, a third state and a fourth state in response to information to be stored in the one non-volatile multi-level memory cell,

when one of the first third states is selected, verifying whether the parameter of the one non-volatile multi-level memory cell has been set to the one state, including comparing the parameter of the one non-volatile multi-level memory cell with one of a plurality of verifying reference parameters including at least a first verifying reference parameter, a second verifying reference parameter and a third verifying reference parameter, the operation of setting the parameter being conducted until it is verified by the operation of verifying that the parameter of the one non-volatile multi-level memory cell has been set to the one state,

reading status of the one non-volatile multi-level memory cell, including comparing the parameter of the one non-volatile multi-level memory cell, with a plurality of reading reference parameters including at least a first reading reference parameter, a second reading reference parameter and a third reading reference parameter,

wherein a conductivity value of the one non-volatile multi-level memory cell is increased in order of the first state, the second state, the third state and the fourth state,

wherein the first reading reference parameter is allocated between the first state and the second state, the second reading reference parameter is allocated between the second state and the third state, and the third reading reference parameter is allocated between the third state and the fourth state,

wherein the first reading reference parameter, the second reading reference parameter and the third reading reference parameter are parameters for a normal read operation in which the information stored in the one non-volatile multi-level memory cell can be read out as output data of a plurality of bits,

wherein the normal read operation includes parallel-comparing the parameter of the one non-volatile multi-level memory cell with the plurality of reading reference parameters using a plurality of sense circuits including at least a first sense circuit, a second sense circuit and a third sense circuit, first input terminals of the first sense circuit, the second sense circuit and the third sense circuit are commonly supplied with the parameter of the one non-volatile multi-level memory cell, a second input terminal of the first sense circuit is supplied with the first reading reference parameter, a second input terminal of the second

LAW OFFICES OF  
SKJERNEN MORRILL LLP  
3 EMBARCADERO CENTER  
SUITE 2800  
SAN FRANCISCO, CA 94111  
(415) 217-6000  
FAX (415) 434-0646

Application No.: 09/759,119  
915218 v1

Express Mail No.: EV259164818US

1  
C1

sense circuit is supplied with the second reading reference parameter and a second input terminal of the third sense circuit is supplied with the third reading reference parameter,

wherein the first verifying reference parameter is allocated above the first reading reference parameter, the second verifying reference parameter is allocated between the first reading reference parameter and the second reading reference parameter and the third verifying reference parameter is allocated between the second reading reference parameter and the third reading reference parameter, and

wherein the plurality of non-volatile multi-level memory cells of the matrix of the rows and the columns are disposed in substantially a rectangle that has a first side, a second side, a third side and a fourth side, the first side and the second side intersect with each other substantially perpendicularly, a plurality of word lines coupled with gate electrodes of floating gate FET's of the multi-level memory cells and the first side of the rectangle intersect with each other substantially perpendicularly, a plurality of bit lines coupled with drains of floating gate FET's of the multi-level memory cells and the second side of the rectangle intersect with each other substantially perpendicularly, a row select circuit is disposed at the first side of the rectangle for coupling with the plurality of word lines, and peripheral circuitry, including a column select circuit, sense circuits, a data conversion circuit and latches, is disposed at the second side of the rectangle.

81.(New) The method of operating the electrically alterable non-volatile multi-level memory according to claim 80,

wherein the operation of setting the parameter includes an erasure operation in which non-volatile multi-level memory cells of one of a byte, a block and a chip level can be erased.

82.(New) The method of operating the electrically alterable non-volatile multi-level memory according to claim 81,

wherein the operation of setting the parameter includes a program operation in which electrons are injected into a floating gate of the one non-volatile multi-level memory cell.

LAW OFFICES OF  
SKJERVEN MORRILL LLP  
3 EMBARCADERO CENTER  
SUITE 2800  
SAN FRANCISCO, CA 94111  
(415) 217-6000  
FAX (415) 434-0646

Application No.: 09/759,119  
915218 v1

Express Mail No.: EV259164818US

83.(New) For an electrically alterable non-volatile multi-level semiconductor memory device including a plurality of non-volatile multi-level memory cells, each of the multi-level memory cells including a floating gate FET having a channel with electrically alterable voltage threshold value, the plurality of non-volatile multi-level memory cells being disposed in a matrix of rows and columns, channels of multi-level memory cells of a group of the plurality of non-volatile multi-level memory cells being coupled in parallel between a bit line and a reference potential, electrons being capable of being injected into the floating gate from the channel in each of the plurality of non-volatile multi-level memory cells, a method of operating the electrically alterable non-volatile multi-level semiconductor memory device, comprising:

controlling an electrical value of at least one non-volatile multi-level memory cell of the plurality of non-volatile multi-level memory cells to a state selected from a plurality of states including at least a first state, a second state, a third state and a fourth state in response to information to be stored in the one non-volatile multi-level memory cell,

when one of the first to third states is selected, verifying whether the electrical value of the one non-volatile multi-level memory cell has been controlled to the one state, including comparing the electrical value of the one non-volatile multi-level memory cell with one of a plurality of verifying reference electrical values including at least a first verifying reference electrical value, a second verifying reference electrical value and a third verifying reference electrical value, the operation of controlling the electrical value being conducted until it is verified by the operation of verifying that the electrical value of the one non-volatile multi-level memory cell has been controlled to the one state,

reading status of the one non-volatile multi-level memory cell, including comparing the electrical value of the one non-volatile multi-level memory cell with a plurality of reading reference electrical values including at least a first reading reference electrical value, a second reading reference electrical value and a third reading reference electrical value,

wherein a conductivity value of the one non-volatile multi-level memory cell is increased in order of the first state, the second state, the third state and the fourth state,

wherein the first reading reference electrical value is allocated between the first state and the second state, the second reading reference electrical value is allocated between

Application No.: 09/759,119  
915218 v1

Express Mail No.: EV259164818US

the second state and the third state, and the third reading reference electrical value is allocated between the third state and the fourth state,

wherein the first reading reference electrical value, the second reading reference electrical value and the third reading reference electrical value are electrical values for a normal read operation in which the information stored in the one non-volatile multi-level memory cell can be read out as output data of a plurality of bits,

wherein the normal read operation includes parallel-comparing the electrical value of the one non-volatile multi-level memory cell with the plurality of reading reference electrical values using a plurality of sense circuits including at least a first sense circuit, a second sense circuit and a third sense circuit, first input terminals of the first sense circuit, the second sense circuit and the third sense circuit are commonly supplied with the electrical value from the one non-volatile multi-level memory, cell, a second input terminal of the first sense circuit is supplied with the first reading reference electrical value, a second input terminal of the second sense circuit is supplied with the second reading reference electrical value and a second input terminal of the third sense circuit is supplied with the third reading reference electrical value,

wherein the first verifying reference electrical value is allocated above the first reading reference electrical value, the second verifying reference electrical value is allocated between the first reading reference electrical value and the second reading reference electrical value and the third verifying reference electrical value is allocated between the second reading reference electrical value and the third reading reference electrical value, and

wherein the plurality of non-volatile multi-level memory cells of the matrix of the rows and the columns are disposed in substantially a rectangle that has a first side, a second side, a third side and a fourth side, the first side and the second side intersect with each other substantially perpendicularly, a plurality of word lines coupled with gate electrodes of floating gate FET's of the multi-level memory cells and the first side of the rectangle intersect with each other substantially perpendicularly, a plurality of bit lines coupled with drains of floating gate FET's of the multi-level memory cells and the second side of the rectangle intersect with each other substantially perpendicularly, a row select circuit is disposed at the first side of the rectangle for coupling with the plurality of word lines, and peripheral

*cont.*  
*C1*

LAW OFFICES OF  
SKJERNEN MORRILL LLP  
3 EMBARCADERO CENTER  
SUITE 2800  
SAN FRANCISCO, CA 94111  
(415) 217-6000  
FAX (415) 434-0646

Application No.: 09/759,119  
915218 v1

Express Mail No.: EV259164818US

circuitry, including a column select circuit, sense circuits, a data conversion circuit and latches, is disposed at the second side of the rectangle.

84.(New) The method of operating the electrically alterable non-volatile multi-level memory according to claim 83,

wherein the operation of controlling the electrical value includes an erasure operation in which non-volatile multi-level memory cells of one of a byte, a block and a chip level can be erased.

85.(New) The method of operating the electrically alterable non-volatile multi-level memory according to claim 84,

wherein the operation of controlling the electrical value includes a program operation in which electrons are injected into a floating gate of the one non-volatile multi-level memory cell.

86.(New) An electrically alterable non-volatile multi-level semiconductor memory device including a plurality of non-volatile multi-level memory cells, each of the multi-level memory cells including a floating gate FET having a channel with electrically alterable voltage threshold value, the plurality of non-volatile multi-level memory cells being disposed in a matrix of rows and columns, channels of multi-level memory cells of a group of the plurality of non-volatile multi-level memory cells being coupled in parallel between a bit line and a reference potential, electrons being capable of being injected into the floating gate from the channel in each of the plurality of non-volatile multi-level memory cells,

wherein an operation of setting a parameter of at least one non-volatile multi-level memory cell of the plurality of non-volatile multi-level memory cells to a state selected from a plurality of states including at least a first state, a second state, a third state and a fourth state is carried out in response to information to be stored in the one non-volatile multi-level memory cell,

wherein, when one of the first to third states is selected, an operation of verifying whether the parameter of the one non-volatile multi-level memory cell has been set to the one state is carried out and includes comparing the parameter of the one non-volatile

Cont.  
C1

LAW OFFICES OF  
SKJERVEN MORRILL LLP  
3 EMBARCADERO CENTER  
SUITE 2800  
SAN FRANCISCO, CA 94111  
(415) 217-6000  
FAX (415) 434-0646

Application No.: 09/759,119  
915218 v1

Express Mail No.: EV259164818US

multi-level memory cell with one of a plurality of verifying reference parameters including at least a first verifying reference parameter, a second verifying reference parameter and a third verifying reference parameter, and the operation of setting the parameter is conducted until it is verified by the operation of verifying that the parameter of the one non-volatile multi-level memory cell has been set to the one state,

wherein an operation of reading status of the one non-volatile multi-level memory cell is carried out and includes comparing the parameter of the one non-volatile multi-level memory cell with a plurality of reading reference parameters including at least a first reading reference parameter, a second reading reference parameter and a third reading reference parameter,

wherein a conductivity value of the one non-volatile multi-level memory cell is increased in order of the first state, the second state, the third state and the fourth state,

wherein the first reading reference parameter is allocated between the first state and the second state, the second reading reference parameter is allocated between the second state and the third state, and the third reading reference parameter is allocated between the third state and the fourth state,

wherein the first reading reference parameter, the second reading reference parameter and the third reading reference parameter are parameters for a normal read operation in which the information stored in the one non-volatile multi-level memory cell can be read out as output data of a plurality of bits,

wherein the normal read operation includes parallel-comparing the parameter of the none non-volatile multi-level memory cell with the plurality of reading reference parameters using a plurality of sense circuits including at least a first sense circuit, a second sense circuit and a third sense circuit, first input terminals of the first sense circuit, the second sense circuit and the third sense circuit are commonly supplied with the parameter of the one non-volatile multi-level memory cell, a second input terminal of the first sense circuit is supplied with the first reading reference parameter, a second input terminal of the second sense circuit is supplied with the second reading reference parameter and a second input terminal of the third sense circuit is supplied with the third reading reference parameter,

wherein the first verifying reference parameter is allocated above the first reading reference parameter, the second verifying reference parameter is allocated between

CONF  
C1

LAW OFFICES OF  
SKJERVEN MORRILL LLP  
3 EMBARCADERO CENTER  
SUITE 2800  
SAN FRANCISCO, CA 94111  
(415) 217-6000  
FAX (415) 434-0646

Application No.: 09/759,119  
915218 v1

Express Mail No.: EV259164818US

the first reading reference parameter and the second reading reference parameter and the third verifying reference parameter is allocated between the second reading reference parameter and the third reading reference parameter, and

wherein the plurality of non-volatile multi-level memory cells of the matrix of the rows and the columns are disposed in substantially a rectangle that has a first side, a second side, a third side and a fourth side, the first side and the second side intersect with each other substantially perpendicularly, a plurality of word lines coupled with gate electrodes of floating gate FET's of the multi-level memory cells and the first side of the rectangle intersect with each other substantially perpendicularly, a plurality of bit lines coupled with drains of floating gate FET's of the multi-level memory cells and the second side of the rectangle intersect with each other substantially perpendicularly, a row select circuit is disposed at the first side of the rectangle for coupling with the plurality of word lines, and peripheral circuitry, including a column select circuit, sense circuits, a data conversion circuit and latches, is disposed at the second side of the rectangle.

87.(New) The electrically alterable non-volatile multi-level memory according to claim 86,

wherein the operation of setting the parameter includes an erasure operation in which non-volatile multi-level memory cells of one of a byte, a block and a chip level can be erased.

88.(New) The electrically alterable non-volatile multi-level memory according to claim 87,

wherein each of the operation of setting the parameter includes a program operation in which electrons are injected into a floating gate of the one non-volatile multi-level memory cell.

89.(New) The electrically alterable non-volatile multi-level memory according to claim 88,

wherein each of the plurality of bit lines transfers information indicating data stored in a memory cell, wherein drain regions of said multi-level memory cells of said group

Application No.: 09/759,119  
915218 v1

Express Mail No.: EV259164818US

LAW OFFICES OF  
SKJERVEN MORRILL LLP  
3 EMBARCADERO CENTER  
SUITE 2800  
SAN FRANCISCO, CA 94111  
(415) 217-6000  
FAX (415) 434-0646

in said matrix are coupled to a first bit line of said plurality of bit lines, drain regions of multi-level memory cells of a second group adjacent to said group in said matrix are coupled to a second bit line adjacent to said first bit line in said plurality of bit lines and drain regions of multi-level memory cells of a third group adjacent to said second group in said matrix are coupled to a third bit line adjacent to said second bit line in said plurality of bit lines.

90.(New) An electrically alterable non-volatile multi-level semiconductor memory device including a plurality of non-volatile multi-level memory cells, each of the multi-level memory cells including a floating gate FET having a channel with electrically alterable voltage threshold value, the plurality of non-volatile multi-level memory cells being disposed in a matrix of rows and columns, channels of multi-level memory cells of a group of the plurality of non-volatile multi-level memory cells being coupled in parallel between a bit line and a reference potential, electrons being capable of being injected into the floating gate from the channel in each of the plurality of non-volatile multi-level memory cells,

wherein an operation of controlling an electrical value of at least one non-volatile multi-level memory cell of the plurality of non-volatile multi-level memory cells to a state selected from a plurality of states including at least a first state, a second state, a third state and a fourth state is carried out in response to information to be stored in the one non-volatile multi-level memory cell,

wherein, when one of the first to third states is selected, an operation of verifying whether the electrical value of the one non-volatile multi-level memory cell has been controlled to the one state is carried out and includes comparing the electrical value of the one non-volatile multi-level memory cell with one of a plurality of verifying reference electrical values including at least a first verifying reference electrical value, a second verifying reference electrical value and a third verifying reference electrical value, and the operation of controlling the electrical value is conducted until it is verified by the operation of verifying that the electrical value of the one non-volatile multi-level memory cell has been controlled to the one state,

wherein an operation of reading status of the one non-volatile multi-level memory cell is carried out and includes comparing the electrical value of the one non-volatile multi-level memory cell with a plurality of reading reference electrical values including at

Cont.  
C1

LAW OFFICES OF  
SKJERVEN MORRILL LLP  
3 EMBARCADERO CENTER  
SUITE 2800  
SAN FRANCISCO, CA 94111  
(415) 217-6000  
FAX (415) 434-0646

Application No.: 09/759,119  
915218 v1

Express Mail No.: EV259164818US



least a first reading reference electrical value, a second reading reference electrical value and a third reading reference electrical value,

wherein a conductivity value of the one non-volatile multi-level memory cell is increased in order of the first state, the second state, the third state and the fourth state,

wherein the first reading reference electrical value is allocated between the first state and the second state, the second reading reference electrical value is allocated between the second state and the third state, and the third reading reference electrical value is allocated between the third state and the fourth state,

wherein the first reading reference electrical value, the second reading reference electrical value and the third reading reference electrical value are electrical values for a normal read operation in which the information stored in the one non-volatile multi-level memory cell can be read out as output data of a plurality of bits,

wherein the normal read operation includes parallel-comparing the electrical value of the one non-volatile multi-level memory cell with the plurality of reading reference electrical values using a plurality of sense circuits including at least a first sense circuit, a second sense circuit and a third sense circuit, first input terminals of the first sense circuit, the second sense circuit and the third sense circuit are commonly supplied with the electrical value of the one non-volatile multi-level memory cell, a second input terminal of the first sense circuit is supplied with the first reading reference electrical value, a second input terminal of the second sense circuit is supplied with the second reading reference electrical value and a second input terminal of the third sense circuit is supplied with the third reading reference electrical value,

wherein the first verifying reference electrical value is allocated above the first reading reference electrical value, the second verifying reference electrical value is allocated between the first reading reference electrical value and the second reading reference electrical value and the third verifying reference electrical value is allocated between the second reading reference electrical value and the third reading reference electrical value, and

wherein the plurality of non-volatile multi-level memory cells of the matrix of the rows and the columns are disposed in substantially a rectangle that has a first side, a second side, a third side and a fourth side, the first side and the second side intersect with each other substantially perpendicularly, a plurality of word lines coupled with gate electrodes of

floating gate FET's of the multi-level memory cells and the first side of the rectangle intersect with each other substantially perpendicularly, a plurality of bit lines coupled with drains of floating gate FET's of the multi-level memory cells and the second side of the rectangle intersect with each other substantially perpendicularly, a row select circuit is disposed at the first side of the rectangle for coupling with the plurality of word lines, and peripheral circuitry, including a column select circuit, sense circuits, a data conversion circuit and latches, is disposed at the second side of the rectangle.

91.(New) The electrically alterable non-volatile multi-level memory according to claim 90,

wherein the operation of controlling the electrical value includes an erasure operation in which non-volatile multi-level memory cells of one of a byte, a block and a chip level can be erased.

92.(New) The electrically alterable non-volatile multi-level memory according to claim 91,

wherein the operation of controlling the electrical value includes a program operation in which electrons are injected into a floating gate of the one non-volatile multi-level memory cell.

93.(New) The electrically alterable non-volatile multi-level memory according to claim 92,

wherein each of the plurality of bit lines transfers information indicating data stored in a memory cell, wherein drain regions of said multi-level memory cells of said group in said matrix are coupled to a first bit line of said plurality of bit lines, drain regions of said multi-level memory cells of a second group adjacent to said group in said matrix are coupled to a second bit line adjacent to said first bit line in said plurality of bit lines and drain regions of multi-level memory cells of a third group adjacent to said second group in said matrix are coupled to a third bit line adjacent to said second bit line in said plurality of bit lines.--

LAW OFFICES OF  
SKOERVEN MORRIE LLP  
3 EMBARCADERO CENTER  
SUITE 2800  
SAN FRANCISCO, CA 94111  
(415) 217-6000  
FAX (415) 434-0646

Application No.: 09/759,119  
915218 v1

Express Mail No.: EV259164818US